NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 4-94

EVALUATION OF MAKO BAM09 HIGH PRESSURE BREATHING AIR COMPRESSOR

GEORGE D. SULLIVAN
DECEMBER 1993

NAVY EXPERIMENTAL DIVING UNIT

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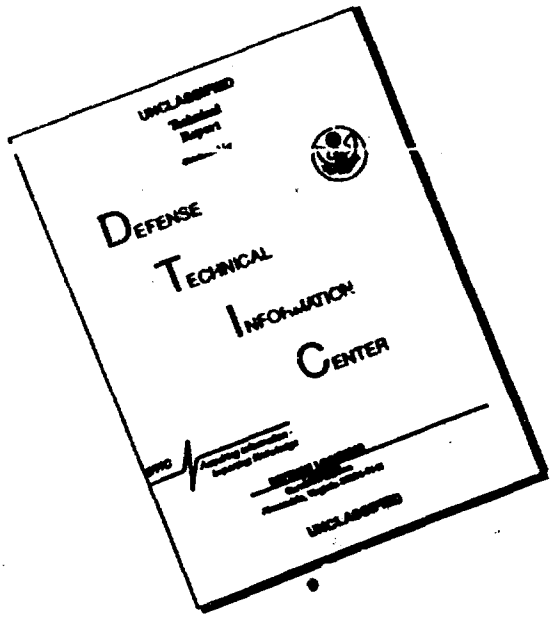

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GEORGE D. SULLIVAN
DECEMBER 1993

Approved for public release; distribution unlimited

Submitted by:

G. D. SULLIVAN
GS-11
Test Director

Reviewed by:

R. I. JOHNSTON
GM-13
Hyperbaric Engineer

B.D. MCKINLEY
LT. USN
Senior Projects Officer

J.R. CLARKE
GM-15
Scientific Director

M.V. LINDSTROM
LCDR, USN
Executive Officer

Approved by:

BERT MARSH
CDR, USN
Commanding Officer

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In response to NAVSEA tasking, Navy Experimental Diving Unit (NEDU) evaluated the MAKO BAM09 High Pressure Breathing Air Compressor from 20 September 1993 to 22 September 1993. This test was to determine if the BAM09, when operating at 5000 PSI, met Navy diving community requirements making it suitable for recommendation for the Approved for Navy Use list published by NAVSEA 00C.

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ILLUSTRATIONS

I. INTRODUCTION

In response to NAVSEA tasking[1-2] a MAKO HIGH PRESSURE AIR COMPRESSOR, MODEL BAM09, ELECTRIC DRIVE was re-tested[3] by Navy Experimental Diving Unit (NEDU). The unit was previously tested and approved by NAVSEA for inclusion in the ANU list at an operating pressure of 3000 psig. The purpose of this test was to re-evaluate the unit at 5000 psig and:

A. Determine if the compressor and Purification System provides compressed air at the required pressures, flow rates, quality and cleanliness required by the U.S. Navy[4].

B. Determine the adequacy of the manufacturer's information, instructions and guidance for the safe operation and overall management of the compressor.

C. Ensure that the compressor purification system discharged clean breathing air required by the U.S. Navy[4].

II. EQUIPMENT DESCRIPTION

A. GENERAL

The MAKO, MODEL BAM09 high pressure, breathing air compressor (Figure 1) is of a four stage, four cylinder, "vee" configuration. All first, second, and third stage cylinder bearings are oil mist lubricated. The fourth stage piston is forced oil lubricated via an oil pump and oil pressure regulator.

The compressor requires approximately 2.4 liters (4 pints) of lubricating oil.

The MAKO compressor unit consists of a compressor block, MK-5-C purification system, auto drain monitoring system, and a drive motor mounted in a compressor module.

The drive unit for this test was a 460 Volt, 3 Phase, 25 Horsepower motor, number M2516T. It is equipped with a hinged motor plate and banded-belt pulley. Rotational torque is transferred to the compressor by a single banded-belt. Electric motors purchased for use with this compressor shall comply with Navy standards for sealed insulation units[5].

The purification system consists of an Interstage separator, auto drain system, auto drain muffler/reservoir, and a MK-5-C Central filter with replaceable cartridges. The interstage separators are installed between the 2nd and 3rd, and the 3rd and 4th stages. The internal operation of the interstage separators is through a nozzle which separates water and oil from the compressed air. The interfilter requires routine maintenance (periodic draining).

The auto drain system blows down the separators at 15 minute intervals. This is accomplished by an electric timer which deactivates a solenoid valve that controls the pressure on a bank of piston type valves isolating the separators from the reservoir. The purification system consists of two cartridge chambers.

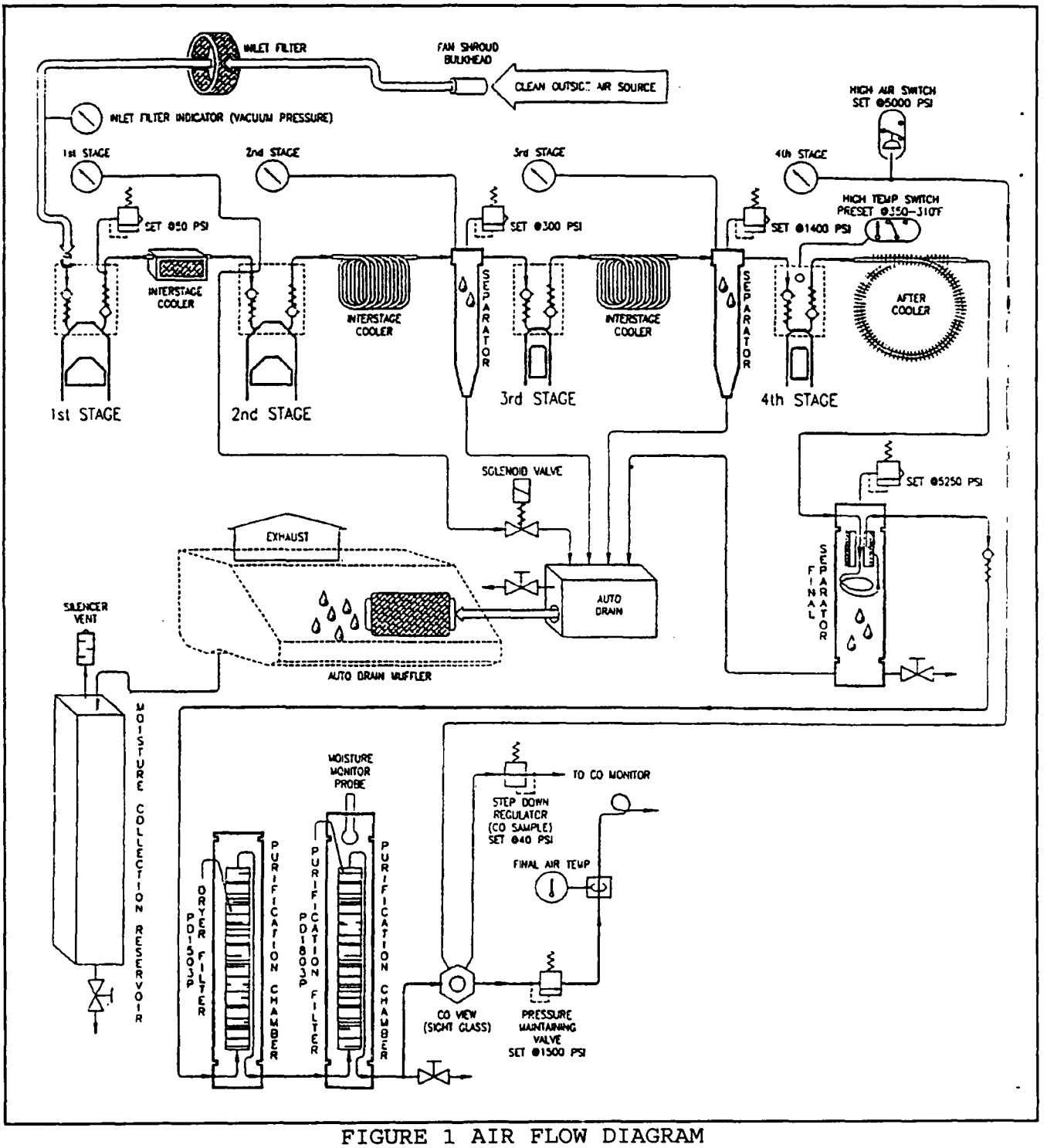

FIGURE 1 AIR FLOW DIAGRAM

Residual oil and water vapors not drained by the auto-drain system are removed by the cartridges. The treated air is free of oil, taste and smell. Carbon monoxide is eliminated when a MAKO filter PART No. PD 1803 is used.

The MAKO BAM09 compressor has a capacity of 680 liters (24 scfm) free air delivered at 345 bars (5,000 psi) with 32 hours of use per cartridge, when operating at 26.6°C (80°F) or less. The Technical Manual[6] states: "Lower pressure or higher temperature will reduce the cartridge life".

A pressure maintaining/non-return valve set at 138 bars (2,000 psi) is provided down-stream from the purification system. This ensures that pressure build-up occurs in the filters during start up and initial compressor air delivery. This achieves constant, optimum filtering, moisture separation, fourth stage piston ring expansion/cylinder sealing, and prevents compressed air return from the storage flasks to the compressor during unit shut down. All four stages of the compressor are protected by safety relief valves. Figure 1 provides a diagram of the compressor air flow/purification system. The compressor comes with an inline CO/Moisture indicator located in the final pressure service line.

The MAKO, MODEL BAM09 comes with one Breathing Air Module Owner's Manual[6] which is divided into the following sections;

1. General Description
2. Main Components
3. Instrumentation and Controls
4. Electric System
5. Installation and Start-up Procedures
6. BAM Operating Procedures
7. Maintenance Procedures
8. Trouble Diagnosis
9. BAM Options

III. TEST PROCEDURE

There are various methods of testing compressor capacities, stability, and reliability[3]. For this compressor evaluation, NEDU chose to continuously run the compressor for extended periods charging a 87.7 liter (3.1 cuft) cylinder from 0 to 310 bars (0 to 4500 psi) and from 0 psi to 345 bars (0 to 5,000 psig).

The compressor and all ancillary equipment was received and set up as per manufacturer's instructions. A Cole Palmer Model 8502-14 temperature monitor and Yellow Springs Instruments 700 Series thermistor probes were attached for measuring compressor discharge and ambient temperatures. An Analox carbon monoxide monitor was used to analyze compressor discharge air both before and after the filter purification system with the sample flow rate set at 3.0 mL per minute. Nitrogen with a 50.8 PPM mixture of Carbon Monoxide (CO) was used to calibrate the high range of the monitor, and ambient air was used to set the monitor's low range at 0.

A gas mixture of 24.4% carbon monoxide and 75.6% nitrogen was injected into the compressor intake by a Victor Equipment Company manual regulator through a Fisher/Porter flow meter.

The introduction of carbon monoxide was adjusted to maintain 50 PPM of carbon monoxide at the inlet to the central purification system. Appendix A shows the recorded data from the Test Log. The unit was operated in an exterior work area, open to ambient temperature and humidity. The testing included subjective evaluation of the system operation but did not include detailed mechanical review of the individual components of the system.

The compressor was operated using two purification/filter cartridges. A total of 25 test hours were expended. The following parameters were recorded: Appendix A is recorded data from the Test Log.

1. Date
2. Time
3. Meter Test Hours
4. Ambient Temperature
5. Compressor Air Discharge Temperature
6. Ambient Humidity
7. Carbon Monoxide PPM (Before/After Filtration)
8. Injected Carbon Monoxide Flow Rate and Percentage
9. Compressor Oil Pressure
10. Compressor Final Discharge Pressure
11. Cylinder Charging Time
12. Compressor free air capacity flow rate

A. AIR DELIVERY

Compressor capacity was determined (28.13 scfm) by calculating the average time to charge a 87.7 liter (3.1 cuft) floodable volume cylinder from 0 to 310 bars (0 to 4,500 psig) and from 0 to 345 bars (0 to 5,000 psig). Calculations are shown in Appendix A-3.

B. AIR SAMPLING

An air sample was taken from the compressor purification system discharge after 1 hour running time. The sample was sent to the NCSC Laboratory, Code 5130, for purity analysis. Analysis of air sample are listed in Appendix B. A second sample was not taken.

C. OIL LUBRICATION

At the beginning of the test, the compressor oil sump level indicated full. Oil level was checked every 30 minutes using the oil level sight glass. Oil consumption was logged in Appendix A. The oil used during the test was MAKO compressor oil. MAKO Technical Manual[6] CAUTION states:

"The MAKO specified lubricant must be used at all times to ensure safe and efficient operation with minimum protection against corrosion."

D. OIL CONSUMPTION

During the 25 hour testing[3], a total of 0.47 liters (1 pint) of oil was added to the compressor.

E. MAINTENANCE

No factory maintenance was scheduled during the first 25 hours of running time.

IV. OBSERVATIONS/RECOMMENDATIONS

A. The compressor system was previously tested and recommended for approval at 3000 psi in NEDU report 4-90. The Bauer purification system was previously tested and recommended for approval at 3000 psi in NEDU report 1-92. This 25 hour test[3] was to upgrade the pressure rating from 3000 psi to 5000 psi.

B. The results of the time required to fill a known volume are recorded in Appendix A.

C. Gauges have no operating parameters listed. It is recommended the following operating parameters be listed on each instrument i.e., ENGINE OIL PRESS 30 - 90 PSI

V. CONCLUSIONS

A. The high pressure air compressor delivers air which meets U.S. Navy standards at an average rate of 28.13 scfm pe·· Appendix A. This meets the manufacturer's specification.

B. The unit is sturdy, reliable and readily maintained.

C. Based on the results of testing the MAKO BAM09 high pressure air compressor system recommended for inclusion by the Navy on the Approved for Use List[7].

D. The vendor and NAVSEA should be contacted prior to purchase to ensure the unit meets the user's needs.

VI. REFERENCES

1. NAVSEA Task 92-002; Evaluation of commercially available divers air compressors. Navy Experimental Diving Unit

2. NAVSEA Task 92-003; Evaluation of commercially available filters for H.P. and L.P. breathing air. Navy Experimental Diving Unit

3. Navy Experimental Diving Unit Test Plan Number 93-33

4. NAVSEA 0994-LP-001-9010 U.S. Navy Diving Manual Volume 1, Rev. 2, Para 5.3.2. Air purity standards

5. MIL-M-17060 E Amendment 1, Sealed insulated systems, (service A use). Navy specification for compressor power source.

6. Breathing Air Module (BAM09) Manual Mako Compressors, Inc. 1634 SW 17 street Ocala, Florida 34474 (904) 732-2268

7. NAVSEAINST 10560.2B Authorized for Navy Jse

APPENDIX A - Test log

MAKO H.P. COMPRESSOR

DATE 20 SEPTEMBER 1993

REAL TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG° F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
1354	5:46	98°	84°	69%	49 PPM	0 PPM	1.5 CC	24.4%	3.41	5,000	1354				40	220	920	1,900	1,000
1500	6:00	97°	108°	69%	49 PPM	3.5 PPM	1.4 CC	24.4%	3.41	5,000		1501	4,500	:36	39	230	1,120	4,500	1,010
1530	6:41	97°	94°	70%	49 PPM	0 PPM	1.4 CC	24.4%	3.41	5,000	1522				39	215	900	1,700	1 000
1600	6:91	97°	91°	71%	49 PPM	3.2 PPM	1.4 CC	24.4%	3.41	5,000		15,55	4,500	:33	39	215	910	1,750	1,010
1630	7:42	96°	110°	71%	48 PPM	0 PPM	1.4 CC	24.4%							39	225	1,140	4,400	1,000

REMARKS
1345 STARTED COMPRESSOR
1354 STARTED TEST
1410 SECURED COMPRESSOR (LOW LUBE OIL PRESSURE)
1441 STARTED COMPRESSOR
1501 COMPRESSOR H.P. SHUT DOWN 4,500 PSI
1504 RE-STARTED COMPRESSOR
1517 SECURED LEAK 4TH STAGE SEPARATOR
1520 STARTED COMPRESSOR
1630 SECURED

APPENDIX A - Test log

MAKO H.P. COMPRESSOR

DATE 21 SEPTEMBER 1993

REAL TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG° F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
0645	7:52	81°	80°	88%	49 PPM	1.8 PPM	1.5 CC	24.4%							40	220	900	1,600	1,010
0700	7:85	83°	98°	87%	48 PPM	0.9 PPM	1.4 CC	24.4%							39	225	1,100	3,700	1,010
0715	8:09	84°	94°	86%	50 PPM	2.0 PPM	1.4 CC	24.4%	3.41	5,000	0708				39	215	900	1,600	1,010
0730	8:39	84°	101°	86%	50 PPM	0 PPM	1.4 CC	24.4%	3.41	5,000					39	225	1,100	3,650	1,010
0800	8:83	87°	103°	79%	50 PPM	0 PPM	1.4 CC	24.4%	3.41	5,000		0738	4,500	:30	39	225	1,040	3,150	1,010
0843	9:50	88°	105°	78%	50 PPM	1.8 PPM	1.4 CC	24.4%	3.41	5,000	0818				39	225	1,080	3,450	1,010
0900	9:79	89°	96°	74%	50 PPM	2.1 PPM	1.4 CC	24.4%	3.41	5,000		0853	5,000	:35	39	215	900	1,600	1,010
0930	10:26	91°	84°	74%	50 PPM	0.8 PPM	1.4 CC	24.4%							39	219	910	1,750	1,010
1000	10:72	92°	102°	71%	50 PPM	0 PPM	1.4 CC	24.4%							39	215	890	1,600	1,010
1015	11:22	secured	-	-	-	-	-	-							-	-	-	-	-
1130	11:22	95°	78°	69%	50 PPM	0 PPM	1.4 CC	24.4%							37	200	860	1,800	1,010
1200	11:72	97°	107°	68%	50 PPM	1 PPM	1.4 CC	24.4%							39	215	920	1,900	1,010
1230	12:20	99°	112°	66%	50 PPM	0 PPM	1.4 CC	24.4%							39	229	1,100	3,900	.,010
1300	12:73	100°	110°	65%	50 PPM	0 PPM	1.4 CC	24.4%			1246				39	215	900	1,800	1,010

REMARKS
0635 STARTED COMPRESSOR
1015 SECURED COMPRESSOR
1130 STARTED COMPRESSOR

NOTE: COMPRESSOR FINAL DISCHARGE PRESSURE WAS 5,000 PSI. THIS PRESSURE MAY HAVE BEEN OBTAIN BETWEEN READINGS

APPENDIX A - Test log

MAKO H.P. COMPRESSOR

DATE 21 SEPTEMBER 1993

REAL TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG° F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	STAR T TIME	END TIME	END PSI		1S T	2ND	3RD	4TH	
1330	13:17	100°	109°	65%	48 PPM	0 PPM	1.4 CC	24.4%	3.41	5,000		1326	5,000	:42	39	215	900	1,600	1,020
1400	13:67	99°	111°	67%	48 PPM	0 PPM	1.4 CC	24.4%							39	220	940	2,000	1,020
1430	14:19	100°	114°	67%	50 PPM	0 PPM	1.4 CC	24.4%							39	229	1,120	3,750	1,000
1500	14:60	99°	100°	67%	50 PPM	0 PPM	1.4 CC	24.4%							39	215	900	1,700	1,020
1530	15:11	99°	110°	64%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	1,000	2,150	1,025
1600	15:56	98°	113°	65%	50 PPM	0 PPM	1.4 CC	24.4%							39	230	1,120	4,500	1,025
1630	16:08	97°	100°	66%	50 PPM	0 PPM	1.4 CC	24.4%							39	215	900	1,600	1,025
1700	16:56	96°	109°	68%	49 PPM	0 PPM	1.4 CC	24.4%							39	225	1,020	2,900	1,025
1714	16:84	94°	111°	70%	50 PPM	0 PPM	1.4 CC	24.4%							39	231	1,090	4,900	1,025
1730	17:09	94°	89°	71%	50 PPM	0 PPM	1.4 CC	24.4%							39	219	900	1,700	1,025
1800	17:63	92°	106°	72%	45 PPM	0 PPM	1.4 CC	24.4%							39	220	980	2,500	1,025
1830	18:12	91°	108°	73%	48 PPM	0 PPM	1.4 CC	24.4%							39	230	1,160	4,600	1,040
1900	18:57	90°	104°	74%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	940	1,950	1,039
1930	19:09	90°	106°	74%	50 PPM	0 PPM	1.4 CC	24.4%							39	230	1,120	4,000	1,039

REMARKS
1445 COMPRESSOR SHUT DOWN LOW OIL PRESSURE (RESET OIL RELIEF VALVE)
1450 STARTED COMPRESSOR
1830 COMPRESSOR SHUT DOWN LOW OIL PRESSURE (RESET OIL RELIEF VALVE)
1835 STARTED COMPRESSOR

The mean time for pressurizing an 87.7 liter (3.1 cuft) flask from 0 to 310 bars (0 to 4500 psi, 307.12 ATA) is: $\frac{36+33+30}{3}$ = 33 minutes, therefore, the charging rate is: $\frac{87.7 \times 307.12}{33}$ = 816.19 SLPM or 28.82 CFM

The mean time for pressurizing an 87.7 liter (3.1 cuft) flask from 0 to 345 bars (0 to 5000 psi, 341.14 ATA) is: $\frac{35+42}{2}$ =38.5 minutes, therefore, the charging rate is $\frac{87.7 \times 341.14}{38.5}$ = 777.09 SLPM or 27.44 CFM

The overall average charging rate is $\frac{816.19+777.09}{2}$ = 796.64 SLPM or 28.13 CFM

APPENDIX A - Test log

MAKO H.P. COMPRESSOR

DATE 21 & 22 SEPTEMBER 1993

REAL TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG° F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
2000	19:58	100°	109°	65%	48 PPM	0 PPM	1.4 CC	24.4%							39	220	900	1,600	1,039
2030	20:08	99°	111°	67%	48 PPM	0 PPM	1.4 CC	24.4%							39	229	1,080	3,650	1,039
2100	20:45	100°	114°	67%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	900	1,650	1,039
2130	20:96	99°	100°	67%	50 PPM	0 PPM	1.4 CC	24.4%							39	223	1,040	3,100	1,039
2200	21:45	99°	110°	64%	50 PPM	0 PPM	1.4 CC	24.4%							39	219	900	1,600	1,039
2230	21:96	98°	113°	65%	50 PPM	0 PPM	1.4 CC	24.4%							39	227	1,060	3,250	1,040
2300	22:47	97°	100°	66%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	900	1,700	1,040
2330	22:96	96°	109°	68%	49 PPM	0 PPM	1.4 CC	24.4%							39	222	1,030	2,950	1,040
0000	23:45	94°	111°	70%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	920	1,800	1,040
0030	23:96	94°	89°	71%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	980	2,600	1,040
0100	23:46	92°	106°	72%	45 PPM	0 PPM	1.4 CC	24.4%							39	219	910	1,700	1,040
0130	24:95	91°	108°	73%	48 PPM	0 PPM	1.4 CC	24.4%							39	222	1,000	2,700	1,040
0200	25:46	90°	104°	74%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	910	1,700	1,040
0230	25:96	90°	106°	74%	50 PPM	0 PPM	1.4 CC	24.4%							39	225	1,005	2,700	1,040

REMARKS
2040 SECURED COMPRESSOR
2045 STARTED COMPRESSOR

APPENDIX A - Test log

MAKO H.P. COMPRESSOR

DATE 22 SEPTEMBER 1993

REAL TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG° F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
0300	26:45	84°	85°	83%	50 PPM	0 PPM	1.4 CC	24.4%							39	219	910	1,700	1,040
0330	26:96	83°	98°	85%	50 PPM	0 PPM	1.4 CC	24.4%							39	222	1,020	2,850	1,040
0400	27:38	83°	91°	85%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	900	1,600	1,040
0430	27:89	82°	98°	84%	50 PPM	0 PPM	1.4 CC	24.4%							39	229	1,080	3,400	1,040
0600	27:89	81°	85°	80%	50 PPM	0 PPM	1.4 CC	24.4%							39	220	1,000	3,000	1,040
0630	28.44	82°	97°	77%	50 PPM	0 PPM	1.5 CC	24.4%							39	225	1,060	3,100	1,040
0700	28:92	82°	97°	76%	50 PPM	0 PPM	1.5 CC	24.4%							39	220	940	2,000	1,040
0730	28:96	80°	70°	80%	50 PPM	0 PPM	1.5 CC	24.4%							39	215	900	1,800	1,040
0800	secured	-	-	-	-	-	-	-							-	-	-	-	-
0830	-	-	-	-	-	-	-	-							-	-	-	-	-
0900	29:75	85°	100°	69%	50 PPM	0 PPM	1.4 CC	24.4%							40	230	1120	3,630	1,040
0930	30:21	87°	99°	68%	50 PPM	0 PPM	1.4 CC	24.4%							40	220	920	1,650	1,040
1000	30:64	88°	102°	70%	50 PPM	0 PPM	1.4 CC	24.4%							40	225	1,060	3,150	1,040
1400	30:89	100°	103°	50%	49 PPM	0 PPM	1.4 CC	24.4%							39	220	920	1,700	1,040

REMARKS
0345 SECURED COMPRESSOR
0350 STARTED COMPRESSOR
0701 SECURED COMPRESSOR (CO METER CALIBRATION)
0730 STARTED COMPRESSOR
0800 SECURED COMPRESSOR
0830 STARTED COMPRESSOR
1000 SECURED COMPRESSOR (ADDED 1 PINT COMPRESSOR OIL)
1348 STARTED COMPRESSOR
1400 SECURED COMPRESSOR

Memorandum 21 SEPTEMBER 1993

To: Dave Sullivan, NEDU

From: Glen Deason, Code 2530

Subject: Analysis of air sample marked MAKO Bam 09 Compressor Hour Sample

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Standard Components

Component	Level	Limit
Oxygen	21.0%	20-22%***
Nitrogen	78.1%	NONE***
Argon	0.9%	NONE***
Carbon Dioxide	74.4 PPM	1000 PPM***
Total Hydrocarbons	1.8 PPM	25 PPM**
Carbon Monoxide	<0.5 PPM	20 PPM**
Methane	1.8 PPM	1000 PPM
Acetone	<0.1 PPM	200 PPM***
Benzene	<0.1 PPM	1 PPM***
Chloroform	<0.1 PPM	1 PPM***
Ethanol	<0.1 PPM	100 PPM***
Freon 113	<0.1 PPM	100 PPM***
Freon 11	<0.1 PPM	100 PPM***
Freon 12	<0.1 PPM	100 PPM***
Freon 114	<0.1 PPM	100 PPM***
Isopropyl Alcohol	<0.1 PPM	1 PPM***
Methanol	<0.1 PPM	10 PPM***
Methyl Chloroform	<0.1 PPM	30 PPM***
Methyl Ethyl Ketone	<0.1 PPM	20 PPM***
Methyl Isobutyl Ketone	<0.1 PPM	20 PPM***
Methylene Chloride	<0.1 PPM	25 PPM***
Toluene	<0.1 PPM	20 PPM***
Trimethyl Benzenes	<0.1 PPM	3 PPM***
Xylenes	<0.1 PPM	50 PPM***

Other Components

Component	Level	Limit
NONE		

C4+	<0.1 PPM	NONE

*Expressed as methane equivalents.
**Limits taken from process instruction #0558-839.
***Limits taken from Navy Dive Manual; Vol. 2, Rev. 3.
**** OSHA Final Rule limits published as of July 1992 (not specified in Navy Dive Manual).

2. The above sample did not show appreciable contamination; all components were within the acceptable range.

Glen Deason HBC

Glen Deason
Chemist

DEPARTMENT OF THE NAVY

COMMANDING OFFICER
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

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